National Defense Industrial Association
3rd Annual
CMMI® Technology Conference
and
User Group
with Technical Co-sponsorship by
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Carnegie Mellon University
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Raytheon
Customer Success Is Our Mission

Estimating Effort for PPQA Using the Raytheon 6σ Process

Raytheon North Texas Software Engineering
Donna Freed

N TX Software Engineering Process Improvement Journey

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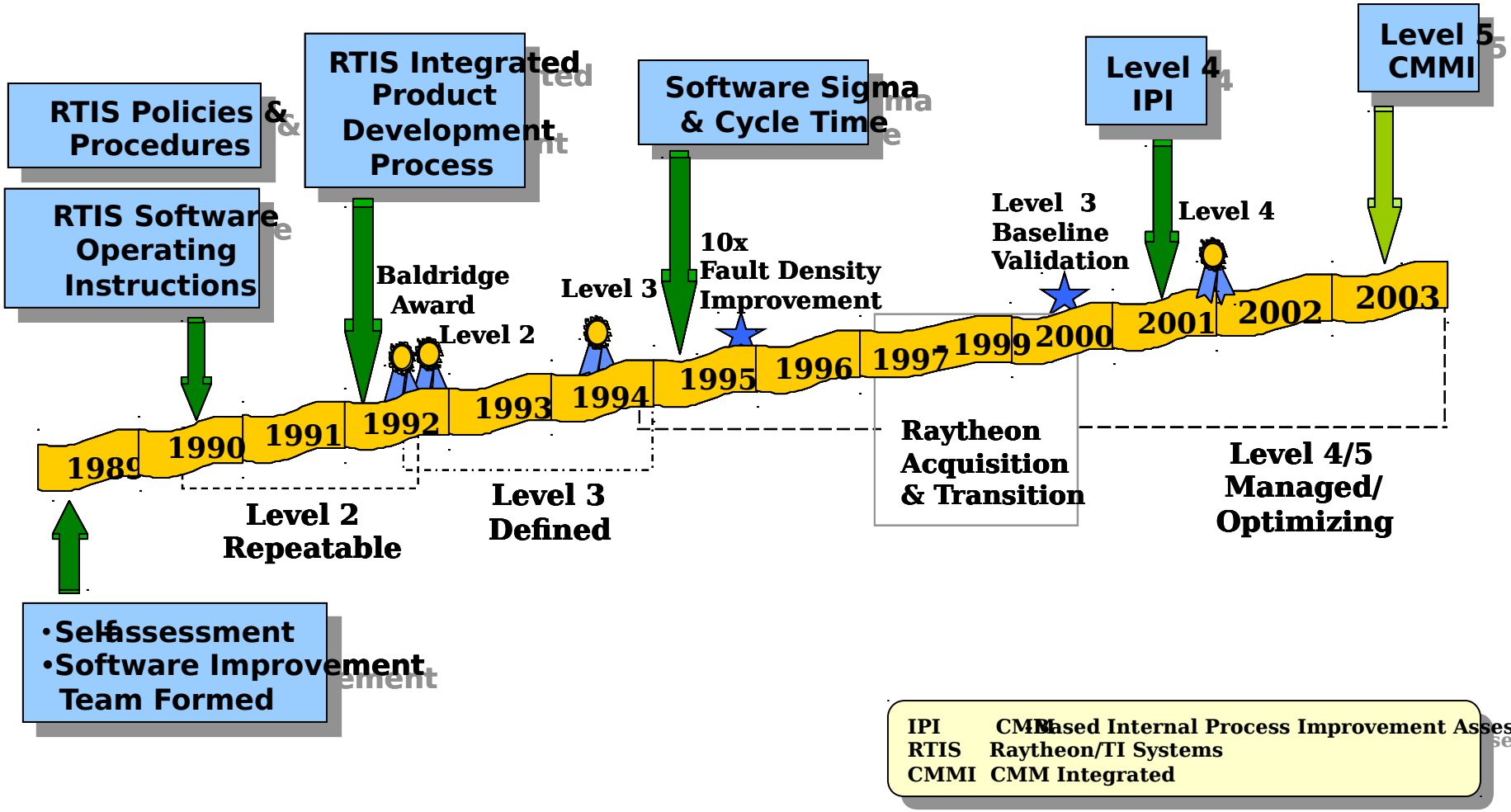

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CMMI at Levels 4 & 5

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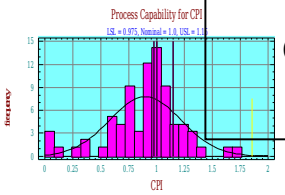
Measure Improvements & Re-baseline

Set Objective Performance & Quality Goals

Stabilize process & Establish Process capability Baseline

CPI



Deploy Improvements

Pilot Improvements

Select & Prioritize Improvements

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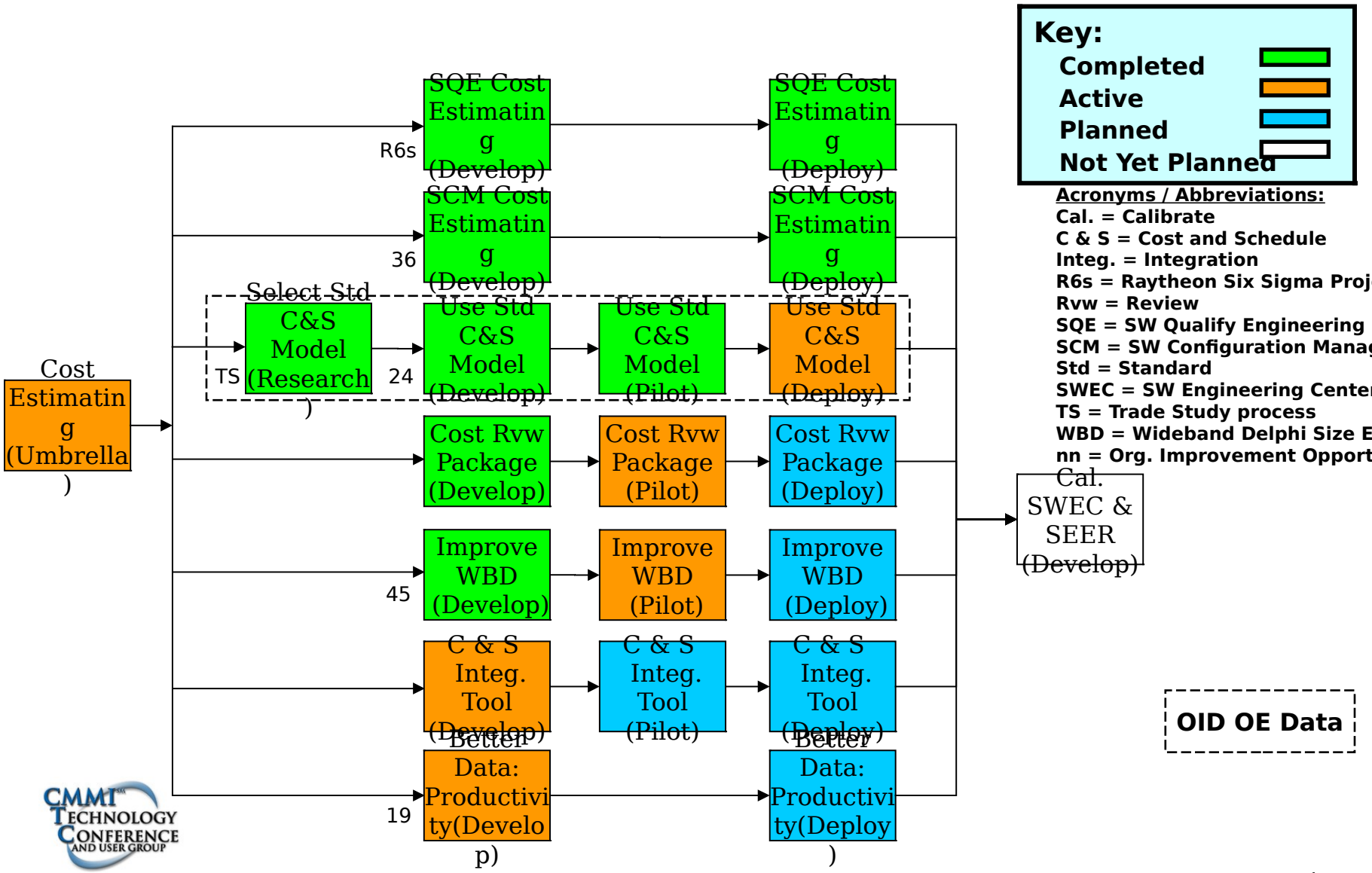
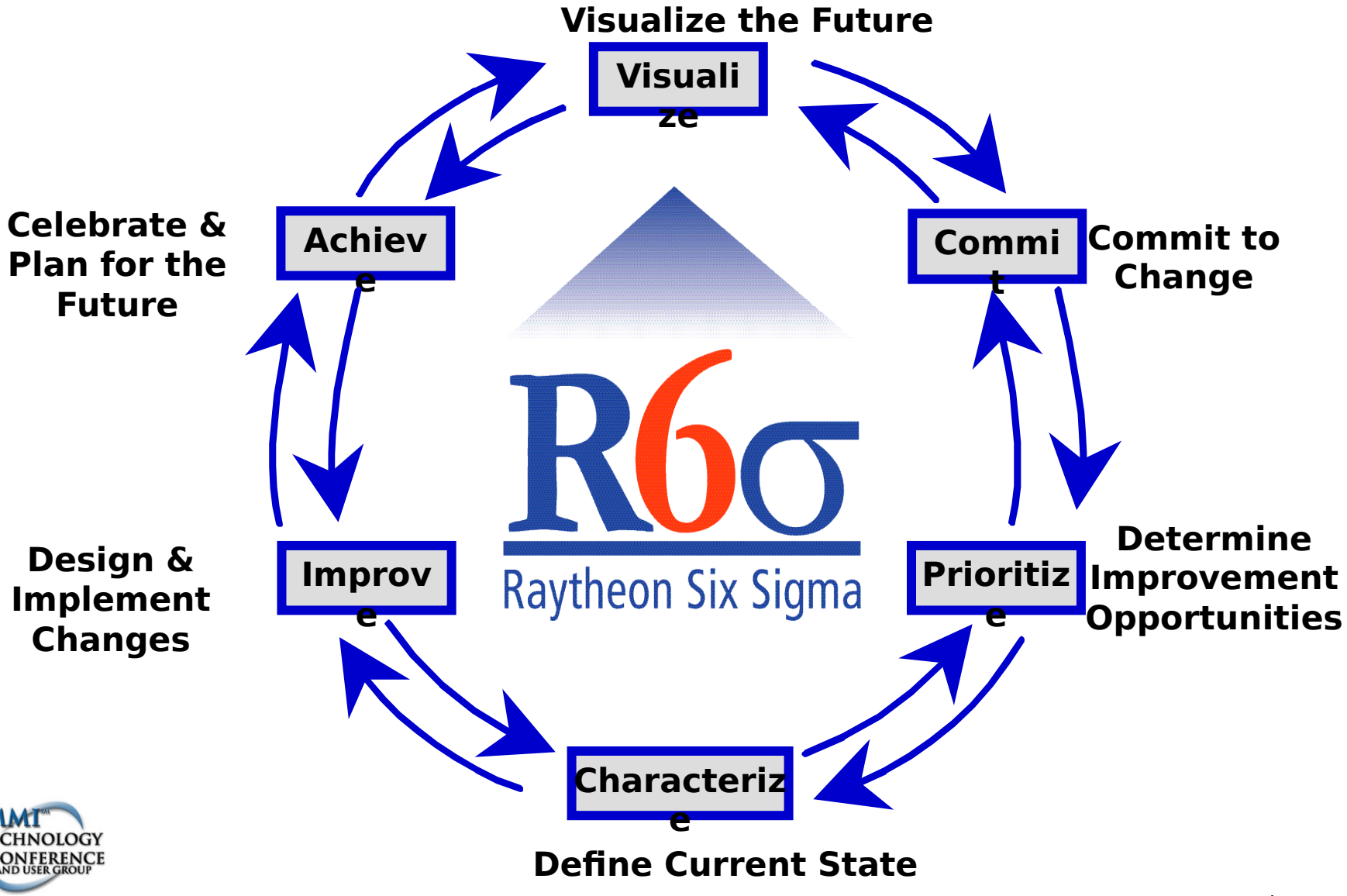
Cost Estimating Improvement Roadmap



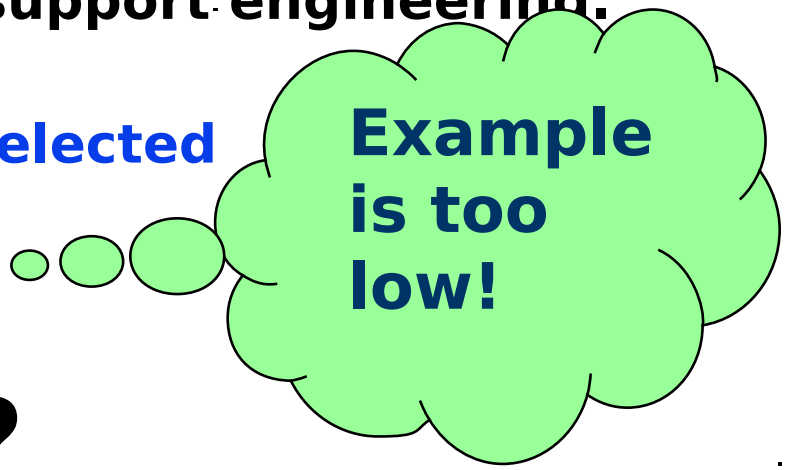
R6σ Process


Visualize the Future
Visualize
Commit
Commit to Change
Prioritize
Determine Improvement Opportunities
Characterize
Define Current State
Improve
Design & Implement Changes
Achieve
Celebrate & Plan for the Future
R6σ
Raytheon Six Sigma

Visualize

- "Imagine the Future"
  - Create a vision of the future with a clear and pressing need for change. Align sponsorship throughout the value stream to maximize our benefits.
  - In late 1999, Raytheon introduced a new methodology for software cost estimating that included the use of "adders" or percentages for support engineering.

PPQA Support	**Minimum**	**Selected**
Defined Process	**x**	**x**
North Texas		**?**



This Sigma project determines North Texas Guidance for PPQA based on actuals for labor hours

Visualize

- **Confidence in the cost estimation process for PPQA support is low:**
  - **Proposals need to be more task based so managers can understand and explain PPQA functions on their programs when presenting proposals.**
    - **Johnny Barrett, SWEC Director, challenge for PPQA as input to December 1999 SQE Planning Session**

- **PPQA took the challenge:**
  - **to verify and justify the PPQA cost percent estimate used in proposals.**
  - **to provide a process for PPQA cost estimation based on historical actuals and tasks required to support the project.**

Commit

- "Commit to Change"
  - Develop a committed sponsor and team aligned with the vision, accountable and energized to make change.
    - Commitment from sponsors (SWEC Director)
    - Commitment from subject matter expert (Software Cost Estimation)
    - Commitment from specialist (SQE Manager)

- To establish commitment, PPQA prepared a detailed break out of the actual labor cost data from 2 historical sources:
  - SMCRS and the “old” SMDB
- Two pareto charts were prepared and presented to the SWECLT, characterizing the actuals.

The wide spread of percentages called into question whether there is a valid percentage.

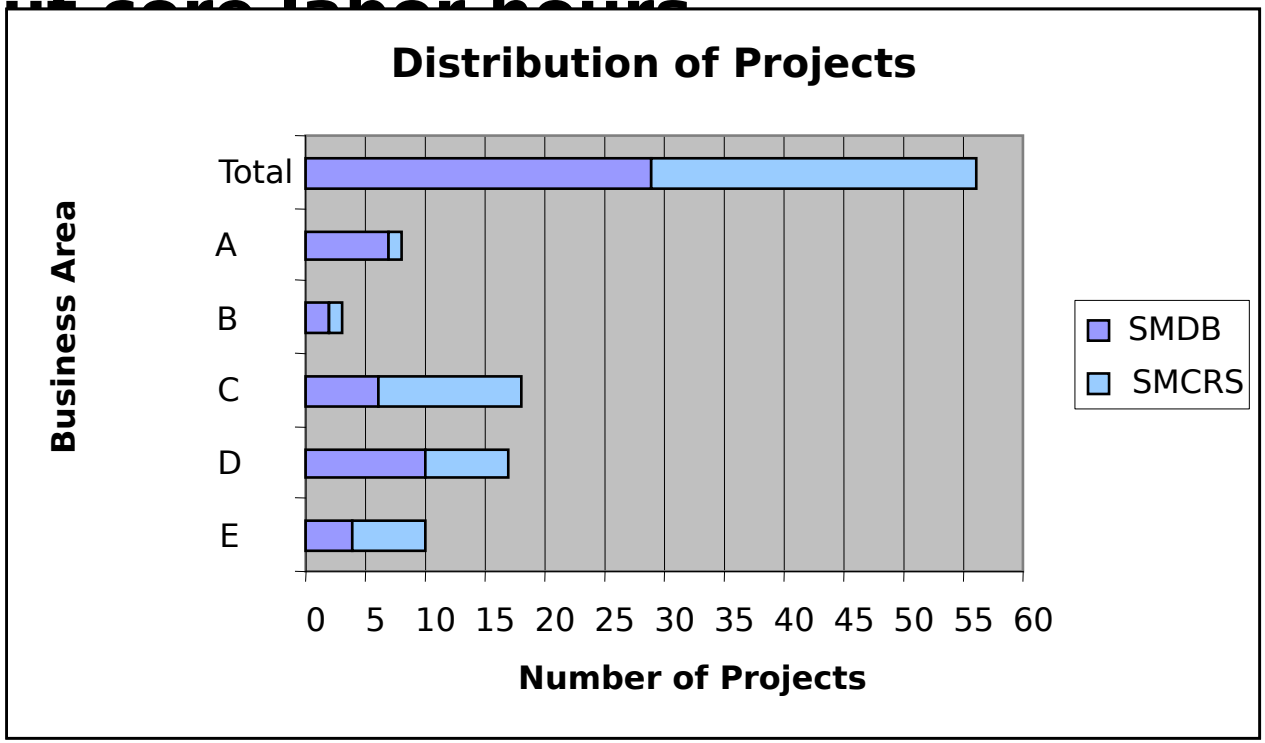
Prioritize

- **"Determine Improvement Priorities"**
  - **Define goals and action plans. Commit resources to focused improvement project(s) in order to realize significant results**

- **Goal/Scope: Is there a valid PPQA "adder" percentage?**
  - **Analyze actual labor hour ranges for PPQA for software engineering in North Texas**
  - **Limited to SQE costs, but approach can apply to other support.**
    - **Johnny Barrett, SWEC Director, sponsored this analysis as a R6σ project**

Characterize--Analyze Actuals

- Combined SMCRS and SMDB into one file for analysis.
- Further refined data by removing all projects without core labor hours



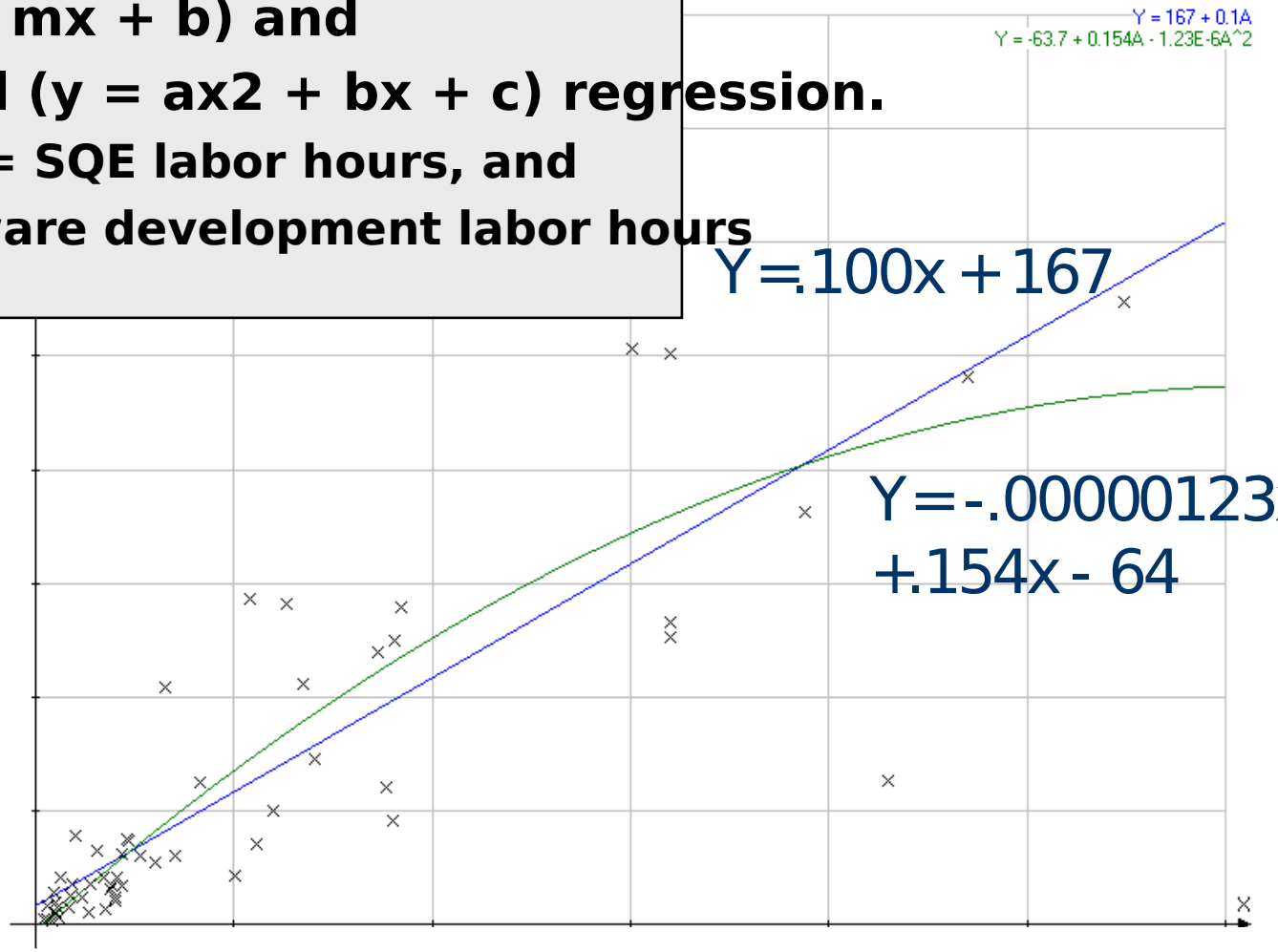
Characterize

- **"Define Existing Process and Plan Improvements"**
  - **Understand and document current state performance (metrics, process flow, and critical factors); translate the current state opportunities into a plan for improvement.**

- **Validate current data**
  - **Break down cost actuals**
    - **Omitted projects with data collection in "bid" or "contract"**
    - **Selected projects with data collection: Final**
    - **Omitted projects with no data or inadequate data in development stages**
  - **Other factors to consider**
    - **Omitted any project with no SQE actuals**

Characterize--Analyze Actuals

- **Actuals were analyzed using both**
  - **linear (y = mx + b) and**
  - **polynomial (y = ax2 + bx + c) regression.**
    - **Note: y = SQE labor hours, and x = software development labor hours**



Characterize-- Detailed Results

- **Coefficient of correlation:**
  - **Core: Linear = .85, Polynomial = .86**
  - **Total: Linear = .83, Polynomial = .84**
    - **Virtually no differences between core and total results--either can be used with the same confidence in the cost model**

- **Residual (remaining base constant for x=0)**
  - **Core: Linear = 167, Polynomial = -64**
  - **Total: Linear = 180, Polynomial = 6**
    - **Polynomial correlation shows significant advantage over linear especially in model based on total hours (because residual is closer to 0)**

Our intuition was incorrect!

Characterize-- Predictions from the model

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- Model predicts declining percentage of SQE effort as size of project increases
- Model works best with medium size projects
- Smaller projects may be inaccurate due to fixed cost in core model
- Not enough data points for larger projects

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Improve – Design and Implement Improvements

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- "Design and Implement Improvements"
  - Design and implement integrated improvements and control systems to maximize value.
- Improvement Plan
  - Publish guidance for PPQA cost estimating
  - Review and approve Cost SMR content for PPQA estimates (Heisenberg principle--the act of observing influences the object being observed)
  - Verify metrics data input for PPQA actuals
  - Enforce requirement to collect PPQA costs separately.

How do we compare?

Northeast SQE Bidding Guidelines vs. N. TX model

SQE Support Adders	NE Guidance	NTX Guidance
Project Size		
Micro	x+ 5.5% (+ / -1.5)	x+ 1.1% (+ / - .9)
Small	x+ 2.55% (+ / - 1.5)	x+ .7% (+ / - .7)
Medium	x% (+ / - 1.0)	x+ .2% (+ / - .9)
Large	x- 1.75% (+ / - .75)	x- .6% (+ / - 1.1)
Very Large	x- 3% (+ / - .5)	x- 2.1% (+ / - 1)

As a percent of Total Software Development effort, including requirements, design, code and test activities.

Achieve – Celebrate Achievements, Build for Tomorrow

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- "Celebrate Achievements, Build for Tomorrow"
  - Deliver measurable results that change the way people think and act, create knowledge, build momentum for continuous improvement, celebrate success, and get people excited about doing Raytheon Six Sigma repeatedly.

- SQE Cost estimating procedure provides consistency for SQE proposal preparation.
- Cost Management review includes the SQE Manager to verify that:
  - Costs fall within guidelines
  - Tasks fall within guidelines for software quality process
- Tasks outside the standard Raytheon software quality process are estimated separately

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Are estimates consistent with the model?

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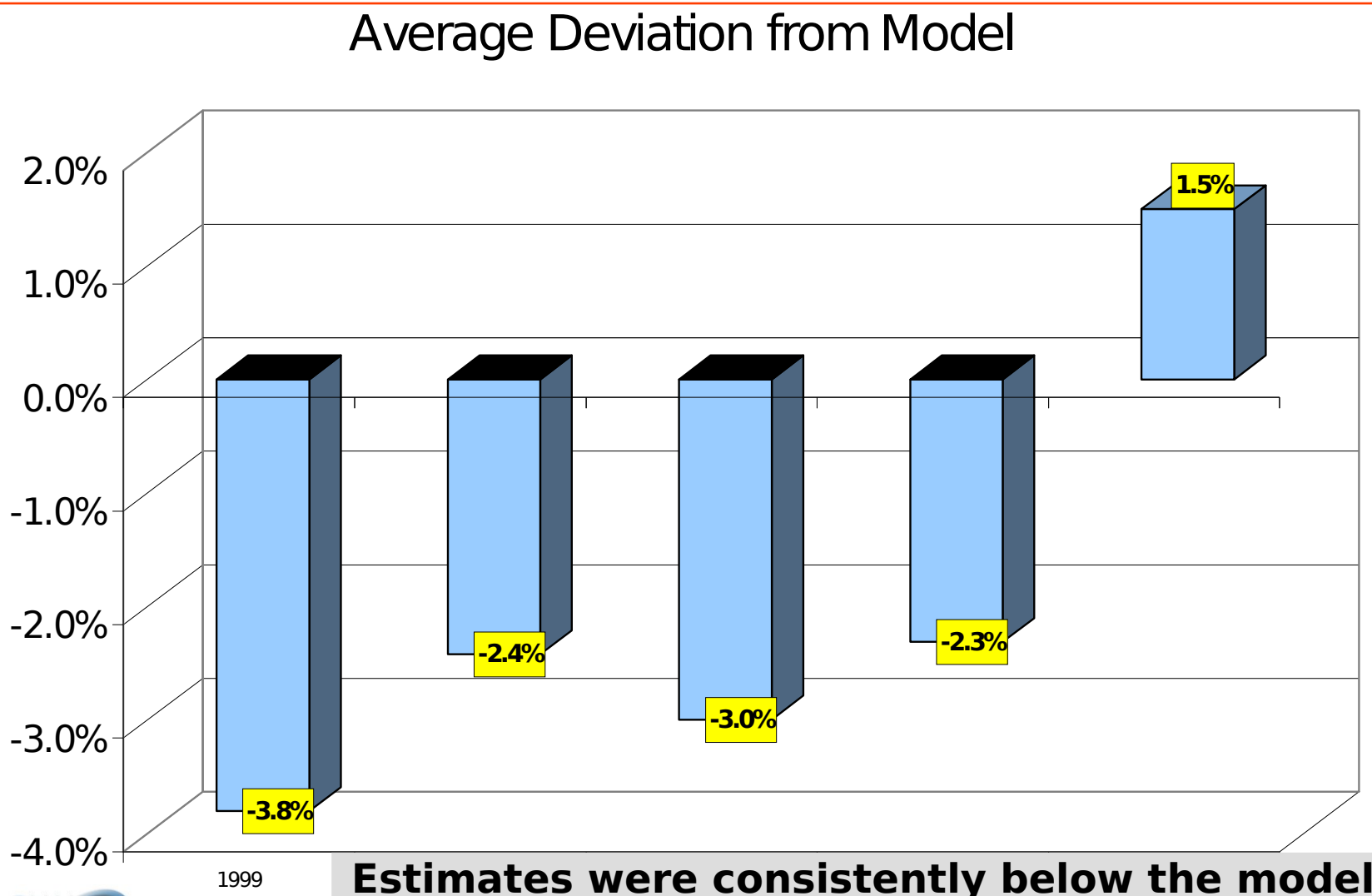

Estimates were consistently below the model based on actuals, until 2003. Guidelines were published in mid 2002.

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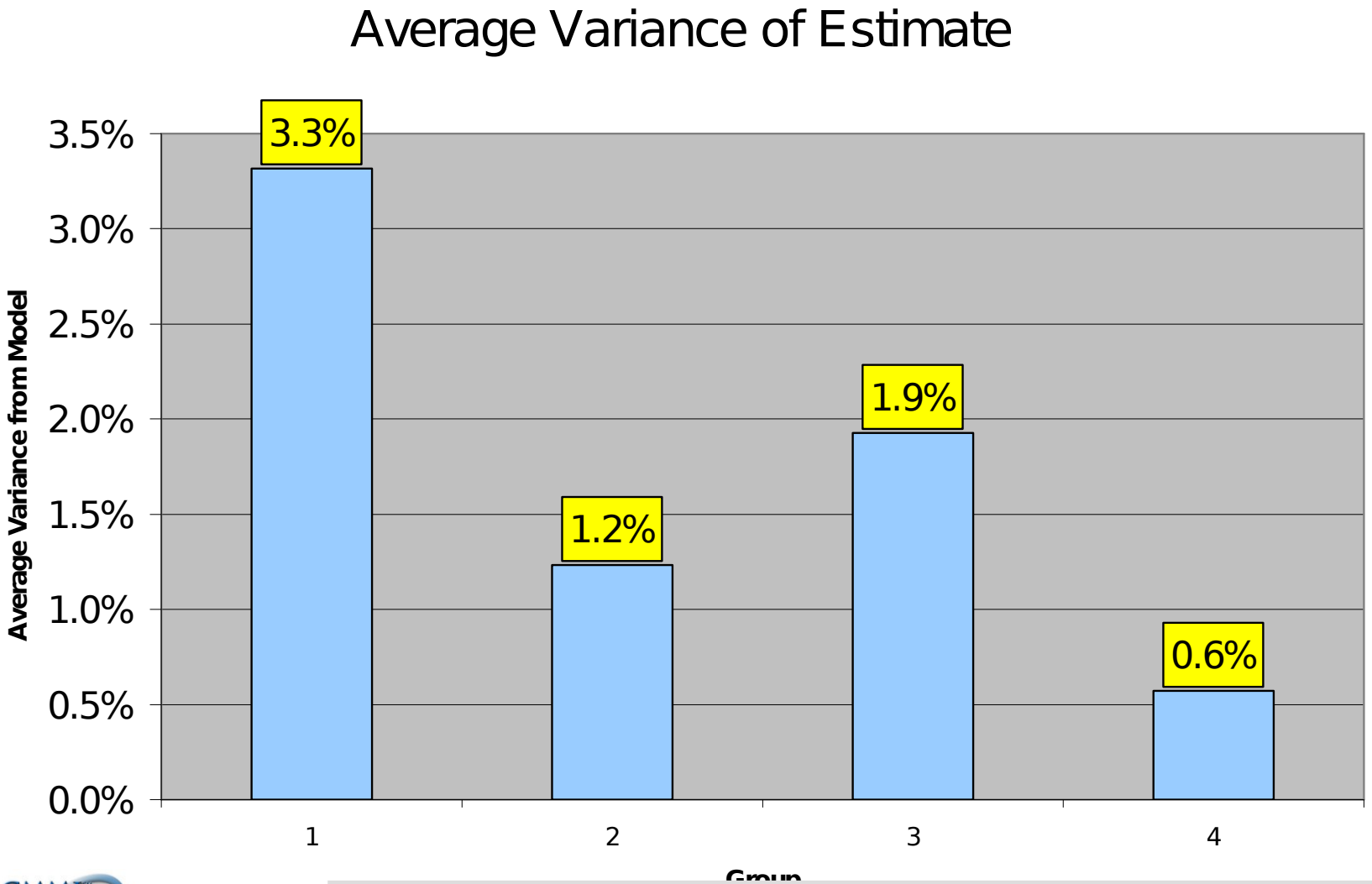
How consistent?



Based on 34 Software Cost Estimates over 4 years.

Summary

- PPQA cost estimating process has been successfully used as guidance for SQE cost estimates on programs in North Texas.
- Started with basic tasks for a CMM level 3 organization.
- Cost estimates are refined as actuals are included in the model.
- A tool for estimating essential PPQA tasks based on the size of projects, with estimates declining in percentage as the size of the project grows.
- Reviewing estimates against guidelines results in estimates which are more consistent with actuals.